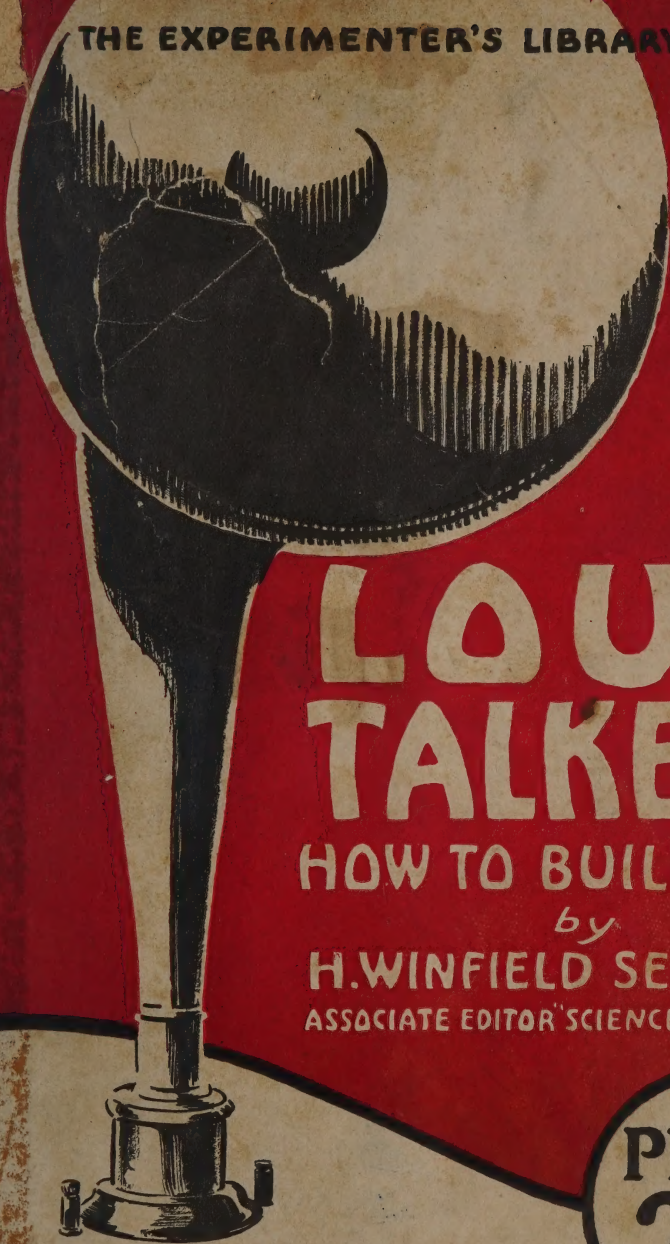


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LOUD TALKERS

HOW TO BUILD THEM

by

H. WINFIELD SECOR, E.E.

ASSOCIATE EDITOR "SCIENCE AND INVENTION"

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H. WINFIELD SECOR

Electrical and Radio Engineer

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Revised and greatly enlarged

Second Edition



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CHAPTER I

WITH the present great boom in radiophone broadcasting, and with thousands of radio enthusiasts installing more elaborate receiving sets daily, the subject of loud-talkers is a very important one for several reasons. First, the loud-talker should intensify the speech or signals, and it should do this clearly, without noticeable distortion. Also, another important factor in the realm of loud-talkers is the cost, and many radio enthusiasts are deterred from using a loud-talker for this reason.

The present book has been written in an effort to supply the necessary data for building a home-made loud-talker, and a number of other valuable hints are given herein for constructing suitable horns to be used with improvised loud-talkers using receivers such as the Baldwin or Brown type.

The first type of loud-talker to be described has a monocoil field, and a liberal sized diaphragm of metal or mica to which is attached a moving coil wound on a light non-magnetic shell, which is supported on the diaphragm by a three-legged spider, as shown in Fig. 1.

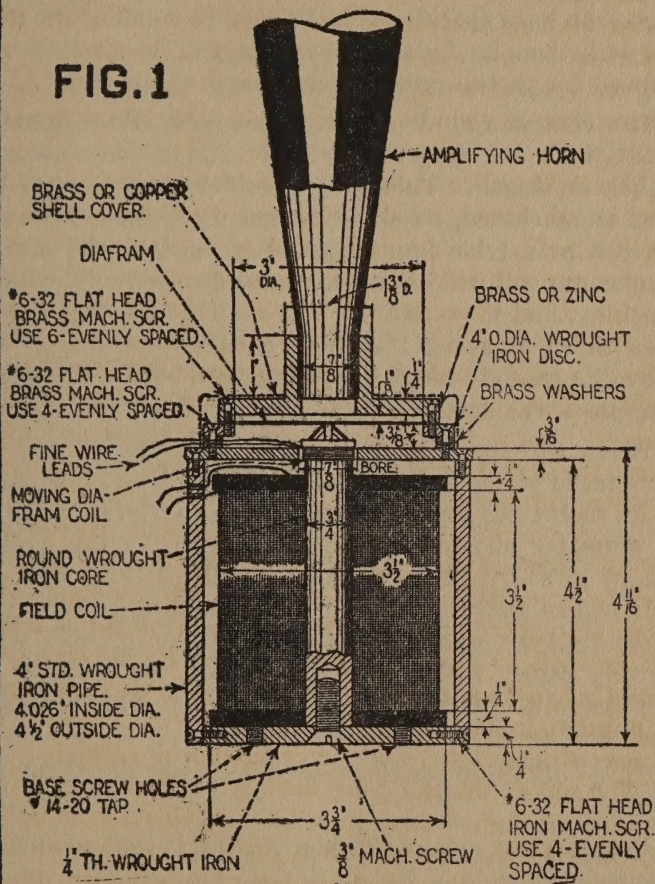
Loud-Talker Field Frame

The Magnavox and other types of loud-talkers provided with separately excited fields, consume from three-quarters to one ampere for the field excitation. Several different windings are provided for in the present design, consuming anywhere from one to two amperes on six volts.

The field coil is enclosed in an iron shell made from a section of 4-inch inside diameter wrought-iron pipe, as shown in Fig. 1. The lower end of this iron pipe, which forms the return path for the magnetism, is closed by means of a wrought-iron or soft machine-steel disc, in the center of which is a hole to accommodate the three-eighth's inch standard machine screw, which anchors the central iron core in position. This end disc is drilled and tapped with a No. 14-20 tap for machine screws; these pass through the wooden base in order to anchor the instrument firmly thereon. Four to six No. 6-32 iron machine screws are equally spaced around the lower end of the wrought-iron pipe, so as to hold the iron disc firmly in position. To make a good job the inside of the iron pipe should be turned out in a lathe for a fraction of an inch so that the iron disc can be accurately and tightly fitted up into the pipe, because if there is much of a gap left in any part of the magnet frame, there will be a loss of magnetic power, even though it is small.

The top of the iron-pipe shell or yoke member is fitted with a wrought-iron disc $3/16$ inch thick, held in place by four to six No. 6-32 inch machine screws, as shown in Fig. 1. In the exact center of this upper iron disc which forms one of the pole-pieces between which the moving coil of the diaphragm oscillates, a hole is drilled, or preferably bored in a lathe, to a diameter of seven-

FIG. 1



eighths of an inch. This hole may have to be a little larger, which fact can be ascertained after the moving diaphragm coil has been wound, because if a little larger wire than here specified is to be used in winding the moving coil, then its finished diameter will be greater than allowed for in the present design and calculations.

The central round iron core measures three-quarters of an inch in diameter by four and seven-sixteenths inches in length. This core should have its upper end filed or machined, so as to be exactly three-quarters of an inch or a trifle less in diameter, so that the moving diaphragm coil will oscillate up and down over it without touching, and it is better to have a little too much clearance in the magnetic air gap between the poles, than not quite enough, for if the moving coil bobbin hits either pole-piece, the action of the instrument will be impaired.

When the core has been properly prepared, and the ends faced off squarely, two round fibre discs one-quarter of an inch thick and three and three-quarters of an inch in diameter should be fitted tightly on to the core as shown in Fig. 1, these discs being placed three and one-half inches apart. The iron core should be covered with three to four layers of paraffined paper or else white writing paper, well shellacked. A hole for bringing out the inside lead is drilled at an angle through the upper fibre disc as seen in the illustration.

Three different windings have been calculated for this field coil.

Probably the most desirable winding is that comprising about five pounds of No. 18 S. C. C. magnet wire, or 1080 feet. The resistance of this winding is about 6.75 ohms, and at six volts the current consumed will be .89 ampere. This corresponds very well with the commercial loud-

talkers which consume three-quarters to one ampere. This winding comprises 1950 turns, and the ampere-turns are therefore 1730, sufficient to give a pretty strong field with a fair incoming signal strength.

For those who do not mind using a little more current, an optional field coil giving a strength of 2690 ampere-turns is composed of approximately the same quantity of wire, No. 16 B. & S. gauge, S. C. C. This winding figures out at 1330 turns or 736 feet of wire, and the resistance comes out 2.96 ohms. Dividing the applied potential by the resistance in ohms, we find that the current consumed is 2.02 amperes.

Both of the windings here specified will operate cool, as considerably more than the usual allowance of 1000 circular mils is obtained for each ampere of current passing through the windings. The circular mils area of No. 16 wire (carrying two amperes) is 2582 C. M. while the area of No. 18 wire is 1624 C. M. With these liberal allowances in areas of magnet wires used, it is permissible to apply as much as twelve volts for periods of one hour or so, which will approximately double the amperage and thus give twice the ampere turns, and about thirty to forty per cent greater magnetic power.

It is always best to solder flexible leads such as a piece of thin lamp cord to the magnet wire inside the bobbin, and wind one or two turns of this lamp cord around the core, as when the magnet wire itself is brought out in the form of a single lead, it is liable to break, and a lot of time and patience will be lost in an effort to repair the lead, and in some cases it may be necessary to rewind the whole coil. Where it is not convenient or possible to procure a piece of four-inch standard iron pipe for the

yoke member of the loud-talker here described, a substitution method may be employed by fitting three iron yoke bars to the center core and upper iron disc as shown in Fig. 1-A. The dimensions of these wrought-iron yoke

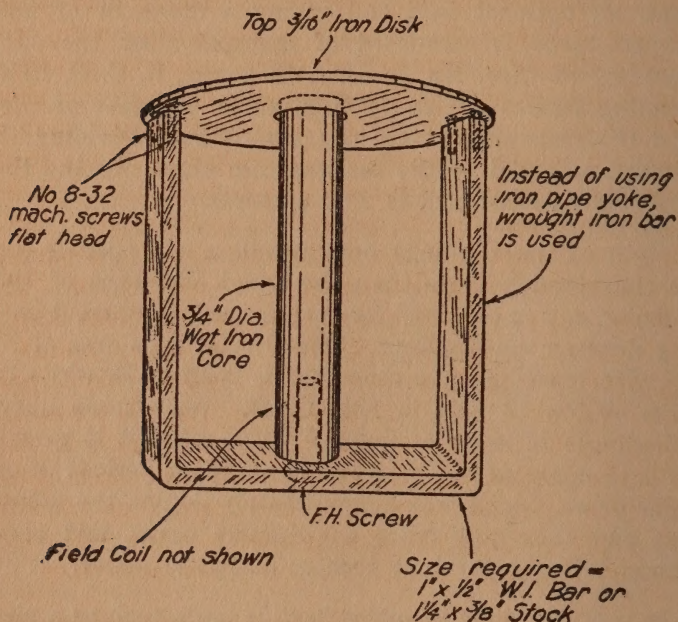


Fig. 1A

members is given in the illustration. However, where the utmost efficiency and the smoothest working of the instrument is desired, the iron pipe shell will prove the best, no doubt owing to the more even distribution of the magnetic flux.

The Diaphragm and Moving Coil

The diaphragm of the loud-talker here illustrated and described is one of the most important parts of the whole mechanism, and a great deal of experimenting can be done with it in order to find just the proper proportions for any given material. One of the leading loud-talkers of this type now on the market, has a diaphragm with a free vibrating diameter of three inches as shown in Fig. 1, this diaphragm being of plain, ordinary tin, about .006 of an inch thick. This diameter is larger than all standard telephone receiver diaphragms, and the thickness may well be increased a few thousandths, but this the builder can readily determine, as the proper thickness and diameter of the diaphragm are also dependent on the weight and construction of the moving coil. This moving coil constitutes one of the most ingenious designs in telephone apparatus brought out in many years. It operates on what is known as the electro-dynamic principle, and when a current passes through the wires constituting the coil, situated in a powerful magnetic field, as in the present case, the magnetic repulsion and attraction causes the coil to move up and down, thus vibrating the diaphragm and reproducing speech in the well-known manner, the same as all other telephone apparatus.

The output terminals of an audion amplifier are connected to the moving coil terminals through the medium of a step-down transformer, having a ratio of about twelve to one, the details for building this transformer being given later on, and illustrated in Fig. 3.

The drawing in Fig. 2 shows all the dimensions of the split brass, bakelite or micarta shell, on which the moving coil is wound. The three- or four-legged spider,

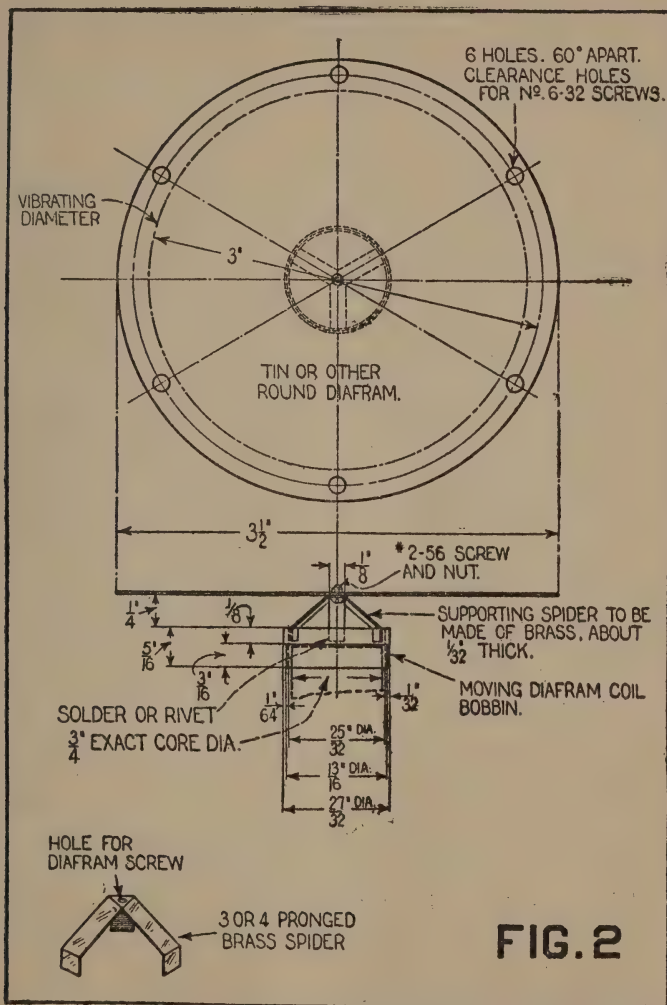
supporting this coil on the diaphragm, is marked and cut out, and the legs then bent downward as shown, with a pair of small pliers. These legs are carefully riveted using cut off pin heads as rivets.

The 12-ohm moving coil here specified, requires two layers (about $18\frac{1}{4}$ ft.), of No. 38 enamelled magnet wire, wound on evenly and then shellacked to hold the turns tightly in place, as this coil will be constantly vibrating when in use. The last turn may be tied in place with a piece of very fine silk thread, or a separate strand of silk thread, and then well shellacked. As heavy leads cannot be very well connected to the moving coil as we would like to arrange them, owing to the drag on the moving coil and diaphragm, which is not permissible, the two leads from the moving coil in the commercial loud-talkers of this type are simply extensions of the fine wire used in winding the coil, which are brought over to the side of the metal rings, supporting the diaphragm, as shown in Fig. 1; they are left of course, a little slack so as to permit the coil to move as freely as possible. These leads may be then soldered to heavier wires, the soldered joints being anchored with wax or in some other way at the edge of the lower diaphragm supporting ring.

The writer has seen a great many of these loud-talkers and heard them when operating with tin diaphragms, and also with japanned iron diaphragms, but one of the best he ever heard, was one fitted with a good mica diaphragm.

Reverting once more to the moving coil structure, it might be suggested that the bobbin ring itself on which the coil is to be wound, might be turned from a piece of brass pipe or bakelite tube by your jeweller. If the constructor is handy on a lathe he may turn it up himself

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from a solid piece of stock or a piece of brass tubing, and if either of these suggestions is not in accordance with the conditions under which the loud-talker is being built, there are several other ways of accomplishing our object.

One of these is to simply, but very carefully, make a brass band out of a piece of sheet stock. The spider supporting the moving coil is preferably attached to the diaphragm by a small screw and nut of the size used in watches or about No. 2-56 thread, and in some cases the spider is soldered or riveted to a metal diaphragm. The metal ring should be split to prevent loss of energy due to induced current therein, as it forms a closed secondary of a transformer. The design for the moving coil bobbin here illustrated, Fig. 2, allows a clearance of one sixty-fourth inch between the inner core and the brass bobbin shell; also a clearance of one sixty-fourth inch between the outside of the moving coil, and the hole in the iron plate, which forms the second pole-piece. As aforementioned, it is better to have a little more clearance than this if the coil and bobbin are not accurately made so as to obviate any chance of the coil striking either the inner pole-piece or outer disc pole-piece. It is sometimes found advantageous to chamfer off the hole in the disc pole-piece, making it larger toward the bottom. Another feature which is used in some of the commercial loud-talkers is to make a separate mounting for the upper end of the iron core which rests within the moving coil member, so that this pole-piece can be separately adjusted and accurately aligned on the iron plate or disc supporting the diaphragm, this short iron pole-piece having a stem about an inch long, which fits down into a hole drilled in the center of the main iron core.

The diaphragm, of whatever materials it is made, must be tightly held in position by six or more screws equally spaced around the periphery as shown in Figs. 1 and 2. These screws, No. 6-32 flat-head brass, (iron may be used if no others are available), slip through holes in the top ring which supports the horn, the holes are tapped for them in the lower or under ring on which the diaphragm rests. Either three, or better four, No. 6-32 flat-head brass screws, are spaced evenly around the under ring, and secured to the top iron disc, as shown in Fig. 1, the proper spacing between the diaphragm supporting ring and the iron disc being taken care of by means of good quality flat washers preferably made of some non-magnetic material. The distance between the supporting ring and the iron disc, may be therefore adjusted to a nicety, until the moving coil is accurately situated in the magnetic gap with respect to the two pole-pieces. This is to be finally adjusted when the loud-talker is completely assembled, and the talking qualities tested. The washers are changed until the disc is evenly spaced all around, and its height varied until the diaphragm gives forth the maximum volume of sound.

Data on Loud-Talkers Actually Built

The moving coil bobbin can be made of brass or other non-magnetic metal, but owing to losses due to induced currents in this metal bobbin (unless it is split), one turned up from bakelite, hard rubber, micarta, or some other hard insulating material is best used.

The following data on loud-talkers, which have been successfully built by radio experimenters, will prove of value and interest to those intending to build their own.

Mr. E. Curnett of Garnet, Kansas, one of the prize winners in the recent "Loud-Talker Contest" in **SCIENCE AND INVENTION MAGAZINE**, built the field of his loud-talker from four steel magneto magnets, as illustrated and described in the January 1923 issue of that journal. No separate magnetizing coil was therefore necessary. The moving diaphragm coil used by Mr. Curnett comprised thirty-three feet of No. 36 insulated magnet wire, having a resistance of 13.75 ohms.

A model corresponding to the design shown in this chapter, with a single magnetizing coil, was built and entered in the Loud-Talker Contest referred to, by Mr. H. L. Jones of Saratoga Springs, N. Y. This loud-talker was tested in the **Radio News Laboratory** and worked nicely. Mr. Jones used a Ford spark coil as the step-down transformer, as did Mr. Curnett. The field coil used by Mr. Jones comprised four pounds of No. 20 D. C. C. magnet wire, and it consumed .46 ampere at six volts. The moving coil of Mr. Jones' loud-talker, comprised 48 feet (20 ohms) of No. 36 enameled copper wire wound on a brass bobbin. Mr. Curnett used a fibre bobbin for the moving coil.

One of the leading makers of this type of loud-talker gave the author some interesting high lights on this class of apparatus, which will be of interest to the builder of such instruments. In the first place the ratio of turns and the size of wire used on the step-down transformers may vary considerably, depending upon the plate voltage used in the last stage of the audion amplifier, and also upon the resistance of the moving coil. The value of the magnetic field in which the coil moves is not so critical, so long as it is a good strong one. This manu-

facturer told the author that resistances as high as fifty ohms in the moving coil had been used successfully, with a corresponding higher resistance secondary on the step-down transformer. The general rule in designing the windings of the secondary of the step-down transformer, and the moving coil winding of the loud-talker, is to have these balance each other or approximately so; although in some cases, depending upon the plate voltage used and other factors, the secondary of the step-down transformer may advantageously be of lower reactance than that of the moving diaphragm coil. The manufacturer referred to states that his engineers have found a resistance of twelve ohms for the moving coil very satisfactory, used in conjunction with a three ohm secondary on the step-down transformer, while the primary of this transformer had a resistance of 1,500 ohms.

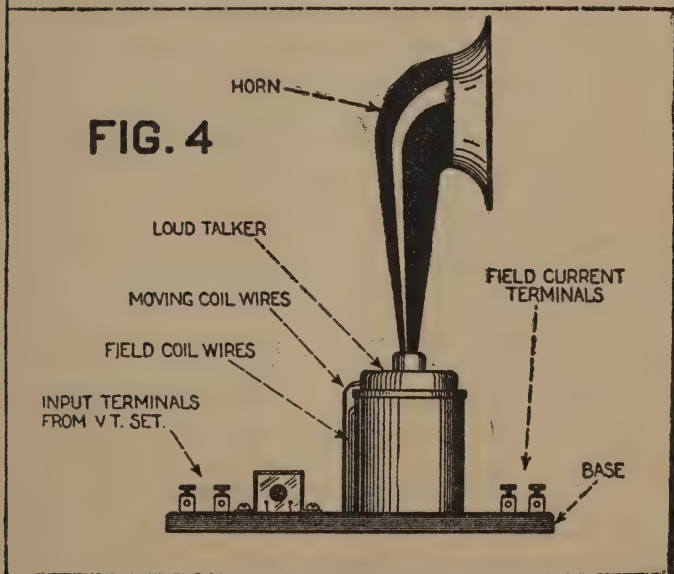
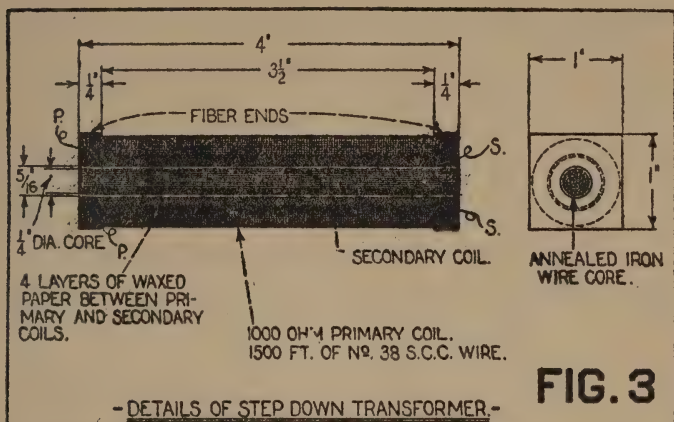
Just to show how the windings vary on different loud-talkers according to the ideas of the designers, or according to results found from practical experiments by the cut-and-try method, the following data on a type R-3 Magnavox proves interesting. Step-down transformer primary 680 ohms; transformer secondary winding .98 ohm; moving diaphragm coil 8 ohms. It is best of course in every instance to leave out taps from the primary as well as the secondary step-down transformers, to permit varying the ratio between the turns of the two windings until the best results, with a given plate voltage, are obtained. When a moving coil with a resistance as high as forty to fifty ohms is used with a corresponding higher resistance and reactance in the secondary of the step-down transformer, a relatively high plate voltage is usually found necessary. Today with power tube amplifiers, plate voltages of 300 to 350 and more, are common.

If loud-talkers of the type here described, do not operate satisfactorily when first built, it may be that the moving coil is striking one of the pole pieces, or that there may be a short-circuit in the winding, etc., which possibilities could be carefully investigated before deciding that the loud-talker will not "talk." Several cases like this have been brought to the author's attention, the builder claiming that the device would not talk at all. In these cases it was found that a sufficiently high plate voltage was not used in some instances, while in others, there were faults in the loud-talker itself, or else a transformer of suitable ratio to balance the other circuit conditions, had not been employed.

To test out the loud-talker itself without its step-down transformer, a microphone and a six volt battery are connected in series with the moving coil, the field being excited of course from dry or storage cells, when the instrument should talk loudly. If it does this, then your loud-talker is built and assembled correctly, and it is only a matter of finding the proper ratio transformer for it depending upon the number of amplifier tubes and the plate voltage to be used, and also depending upon what resistance the moving coil has been wound to.

Details of Step-Down Transformer

It is the usual practice with loud-talkers of this type to use a step-down transformer having a primary resistance of about 1000 to 1500 ohms, to be connected to the audion amplifier; while the secondary coil, connected to the small moving coil of the loud-talker, is wound to have a resistance of approximately the same or else a somewhat lower resistance, say 3 to 5 ohms.



Telephone induction coils or small spark coils, such as the Ford ignition coil, having resistances somewhere in the vicinity of those specified, and resistances fairly close to the values necessary, make a very good step-down transformer. Other transformers of the closed-core type, such as those used for modulation purposes, if the ratio and resistance values are anywhere near those specified may be successfully employed. The Bristol loud-talker uses a closed core transformer of the shell type. The Magnavox and similar loud-talkers, both use open core step-down transformers like that in Fig. 3.

This transformer may be wound with wire readily available, say No. 27 enamelled for the secondary, and No. 38 for the primary. The bobbin for winding the step-down transformer, comprises a thin fibre or paper tube, one-quarter inch inside diameter with a one thirty-second inch wall, and measuring four inches long. On either end two square fibre or wooden blocks, one-quarter inch thick, are glued in place, holes being drilled diagonally through the blocks, to bring out the leads from the inner winding through. The fibre tube is filled tightly with straight lengths of very soft annealed iron wire, about No. 20 or 22 gauge; or as is the case in one of the commercial types, this tube may be filled with thin strips of annealed transformer iron. Another way which has been employed, is to take a long strip of annealed iron stock such as stove-pipe iron, and roll this tightly so as to form a solid bundle and slip the roll into the tube. The writer has designed many induction coils and transformers, and firmly believes in the use of the best quality annealed iron wire tightly packed, and the finer the better for this particular instrument. Another trick which works well with induction coils, in general, is to fill the

core tube with soft iron filings, which can sometimes be obtained from machine shops, the end of the tube being then plugged up with corks, well glued. Cast-iron filings are very good for the purpose.

The secondary winding is first wound on the bobbin, and this may comprise about 60 feet of No. 27 B. & S. gauge, S. C. C. magnet wire, or enamelled wire may be used. This gives about 3 ohms resistance, and if a Wheatstone bridge is handy, the resistances of the windings may be checked up while the windings are being put on. The secondary may comprise 75 feet No. 26 magnet wire, if this is more readily obtainable. Leave out a tap after winding on half of the wire, so as to obtain a resistance of 1.5 ohms. Try both this and the 3 ohm resistances. This comes in handy for experimenting. After the secondary has been wound on, four or five layers of waxed paper are placed over it, and the 1000-ohm primary coil is started. This will require 1500 feet of No. 38 S. S. C. or enamelled copper magnet wire. A 1500-ohm winding requires 2280 feet of No. 38 wire. For high power amplifiers and high plate voltages the 1500-ohm primary coil is preferable. In winding this fine wire it will be found desirable and in fact necessary every now and then to place a layer of waxed paper between the layers in order to keep the coil fairly smooth as the winding progresses, and in all the windings used in this loud-talker, care should be taken to wind on the layers evenly. The proper connection of the secondary and primary windings of the step-down transformer to the loud-talker and the audion receiving circuits, are given in Fig. 5.

The assembly of the step-down transformer and loud-talker unit with horn, is shown in Fig. 4. They should

be mounted on a wooden base, and a binding post provided for the input terminals as well as the field excitation terminals. On the same base may be mounted a rheostat having five to ten ohms resistance, for regulating the strength of the loud-talker field current, as this has a lot to do in some cases with the clarity of speech.

Connection of Loud-Talker to Vacuum-Tube Amplifier Set

The question is frequently asked, especially by beginners in radio, as to whether or not a loud-talker can be operated on a crystal detector receiving set. The answer is emphatically "no," as there is not sufficient energy to energize such an instrument as a loud-talker, or at least those of the general type here discussed. In general, for radio receiving sets located at a fair distance from a radiophone broadcasting center, the receiving set should be fitted with at least a detector and two steps of audio frequency amplification in order to operate successfully a loud-talker of this or similar type.

A vacuum-tube detector and two-step amplifier receiving set will operate a loud-talker nicely within five or ten miles of a broadcasting station, from the writer's experience, but if you want a real volume of sound sufficient to fill one or two large rooms, so as to make the speech and music really enjoyable for family and friends, it is desirable, for distances of 20 to 35 miles or more, to use a third stage of audio-frequency amplification. The writer feels that if he explains just what he has been using for several months successfully in his home at a distance of 30 miles from broadcasting stations in Newark, that the details will probably prove of value to those who are having trouble with their sets or are just entering the radio game.

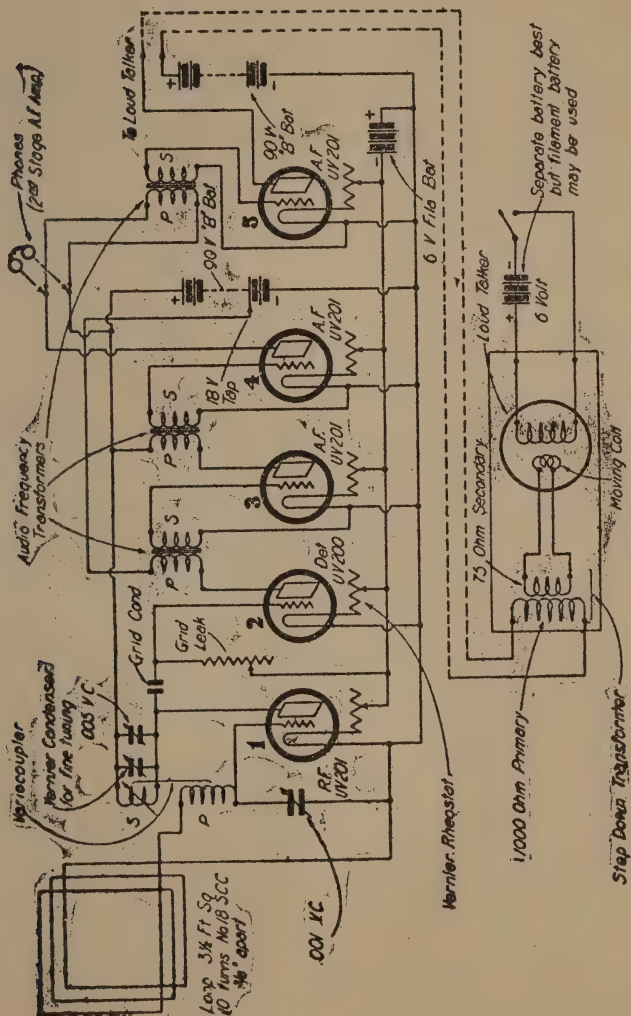


Fig. 5
Diagram showing connection of loud-talker to V. T. amplifier; separate storage battery for loud-talker field magnet is shown

The loud-talker here described is shown in use on a five-tube set, which has been working very successfully through the summer months with a loop aerial three and a half feet square, and as good results are now obtained as with an outdoor two-wire antenna 125 feet long and 40 feet above the ground used during the past winter. To boost the small amount of energy picked up in the loop, which comprises ten turns of No. 18 S. S. C. copper magnet wire spaced three-eighths inch apart, one stage of radio frequency amplification is utilized. A variocoupler with adjustable primary is used to give regenerative effects in the circuit, and thus improve amplification powers, and very sharp tuning is obtained with this simple circuit arrangement. The tuning of the loop aerial circuit is taken care of by the .001 M. F. variable condenser indicated. Across the secondary of the variocoupler is placed a .0005 M. F. variable condenser, and in shunt with it is a vernier condenser for extra fine tuning, once a station has been tuned in roughly with the other condensers. A standard grid condenser is connected in series with the grid of the detector tube No. 2, and from this side of the circuit to the filament there is placed an adjustable grid leak having six taps of one-half megohm each; one megohm, or two sections of the grid leak are now in the circuit.

The standard set, as it was used up to about a month or so ago, was equipped with two stages of audio frequency amplification, comprising two A. F. transformers as shown, and two amplifier vacuum tubes, Nos. 3 and 4. A vernier rheostat is used on the detector tube No. 2, and one was also tried with excellent results on the radio frequency amplifier tube No. 1. Right here it is well to point out that if the set tends to howl and squeal, es-

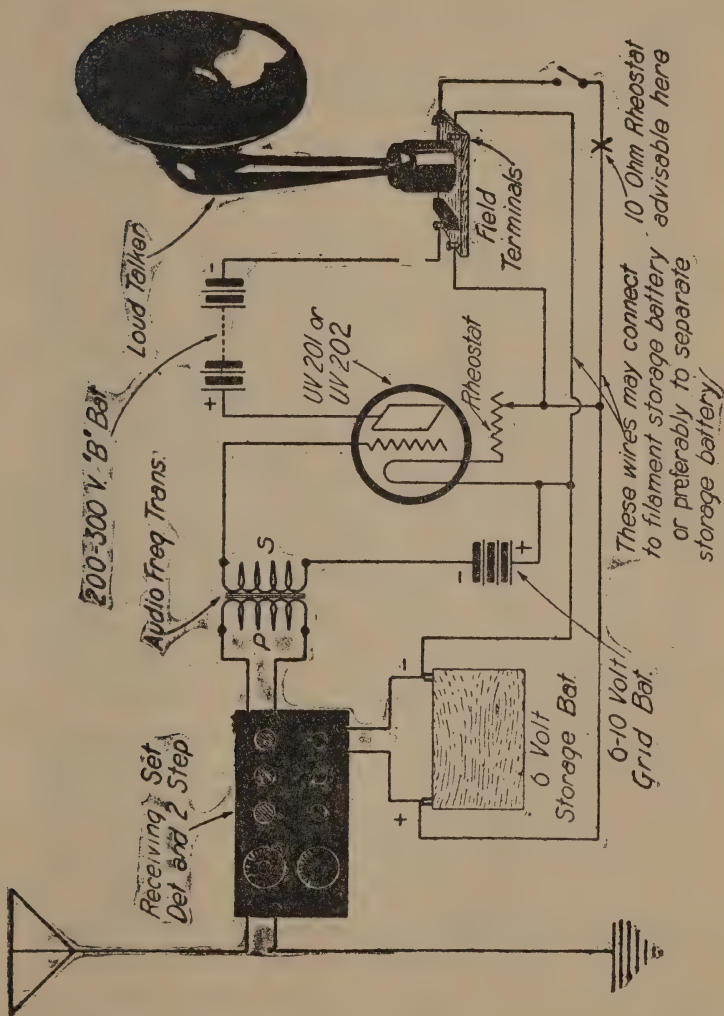


Fig. 6

Diagram showing third stage of audio frequency amplification and connection to loud-talker

pecially when using three stages of audio frequency amplification, that the strength of signals or speech can be retained by reducing the filament brilliancy in the R. F. vacuum tube No. 1 and the detector tube No. 2. As these two tubes have so much to do with the efficient operation of the set, it is at once seen that vernier rheostats are very desirable, and once you use them you will never be without them.

The third stage of audio frequency has been tried both with separate "B" battery as here shown, and also in conjunction with the old "B" battery, used on a four-tube set. A tendency to howl and squeal was always present when trying to use a common "B" battery and five tubes, and to "keep peace in the family" a separate 90-volt "B" battery has been finally adopted for the plate circuit of the third audio-frequency tube. This prevents cross currents from flowing, and helps in other ways. This is especially true where a power tube is used in the third stage of audio-frequency amplification, for instance, a five-watt vacuum tube. If the circuit here shown does not give enough volume, then it is desirable to employ a five-watt power tube with a plate potential of 200 to 300 volts, instead of the "B" battery indicated in Fig. 6.

Referring to Fig. 5 once more, in the five-tube receiving set, a six-volt, 80-ampere-hour storage battery lasts about one week on a charge, operating the five tubes and loud-talker, using the set every evening for one and a half to two hours and sometimes more. A larger storage battery is desirable for this load of six to seven amperes, unless the battery is charged by the operator himself, when, of course, a smaller battery is all right.

Some radio experts claim that loud-talkers with separately excited fields, should have these field windings

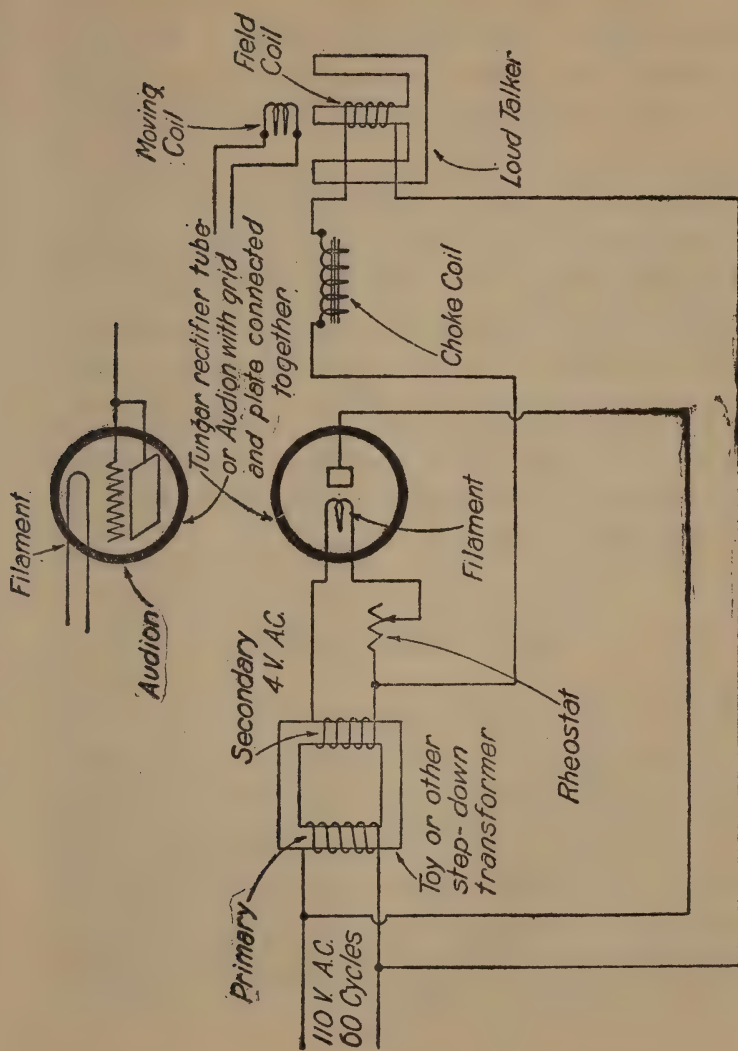


Fig. 7
How to use A. C. house lighting current for the field magnet of a loud-talker

always excited from a separate storage battery, and while this is so in some cases, and of course, advisable when possible, the writer has seen a number of excellent receiving sets operating with a common storage battery for filaments and loud-talker.

The loud-talker may be operated from an A. C. supply such as the 110-volt, 60-cycle light circuit in your home, and the diagram in Fig. 7 shows one of the latest circuits used by an expert at the United States Bureau of Standards, Washington, D. C., for this purpose. The 110-volt, 60-cycle A. C., is rectified through a tungar rectifier tube, and this rectified A. C. is passed through the field winding of the loud-talker, using simply a choke coil connected in series. This choke coil is constructed as follows: On a laminated sheet-iron core one-half inch square by five inches long, is wound 1200 to 1500 turns of No. 24 enamelled magnet wire.

Power-Amplifier Circuit

The diagram in Fig. 6 shows a circuit for a power-amplifier tube, such as a five-watt tube, with a 200- to 300-volt separate plate or "B" battery, together with a loud-talker, and a grid battery of ten volts or more as may be found necessary to stabilize the circuit. This grid battery may comprise ordinary dry cells or flashlight cells. Any good type of audio-frequency transformer is used to couple the power-tube circuit with the detector and two-step receiving set; the field coil of the loud-talker being excited either from the filament storage battery or else a separate storage battery.

CHAPTER II.

Bi-Polar Field Loud-Talker Made From Odd Parts.

THE mechanical details of this ultra-powerful loud-talker are quite simple and the parts required in building it are relatively few. Therefore, the clever radio and electrical experimenter should find little difficulty in building one of these instruments. For one thing, after the powerful electro-magnet has been built, or else obtained from the usual junk box, as it does not have to be exactly like the one here shown either in size or magnetic power, the builder may save himself a lot of trouble by using a good sized phonograph reproducer, or perhaps a watch case telephone receiver, or again, the diaphragm end of a large sized Bell telephone receiver which holds the diaphragm; which will serve as the mounting and opening for the sound amplifying horn.

Building the Electro-Magnet

The direct current electro-magnet shown in Fig. 1 has been designed especially to operate on storage-battery current; but it can be wound with proportionately smaller wire, so as to be operated on 110-volt direct current where desired. The dimensions of the winding bobbins or spools are given in the drawing Fig. 1. The spools measure six inches between the bobbin cheeks, and each winding when finished measures approximately $2\frac{1}{8}$ inches in diameter.

The core, as well as the pole-pieces and the yoke are made of the best grade of annealed wrought iron pro-

curable. It should be as soft as possible, so as not to retain any appreciable degree of residual magnetism. The wrought-iron magnet cores can be cut from a piece of 9/16 inch diameter round bar stock and should have their ends faced off in the lathe, or else filed perfectly flat and true. The length of the core is $6\frac{1}{2}$ inches; the lower ends of the bobbins are provided with 3/16 inch fibre cheeks, measuring $2\frac{1}{4}$ inches in diameter and tightly fitted on the core; while the two upper ends are to be provided with fibre cheeks 5/16 inches thick, about $2\frac{1}{4}$ inches in diameter.

Suitable holes should be drilled in the two lower bobbin ends through which to pass the lead wires from the magnet windings. Before winding the spools the iron core should be carefully covered with about three layers of thin oiled linen or shellacked paper. Paraffined paper is also good.

Each of these spools will require approximately three pounds of No. 20 single cotton covered copper magnet wire (for 2 coils in series on 24 volts or in multiple on 12 volts); or three pounds of No. 17 single cotton covered wire, with two coils in parallel for six volts or in series for twelve volts. The two spools should be wound evenly in layers on a lathe if possible, or else a small winding rig can be fixed up for the purpose. When the spools have been wound full the outside layer should be covered with a piece of heavy cloth or string, shellacked and glued in place to protect them.

The wrought-iron yoke connecting the bases of the magnetizing coils and core is made of 1-inch by $\frac{1}{2}$ -inch stock, about four inches long; the yoke is preferably drilled to accommodate two $\frac{1}{4}$ -inch No. 20-thread machine screws for which the cores have been tapped at

LOUD TALKERS—HOW TO BUILD THEM

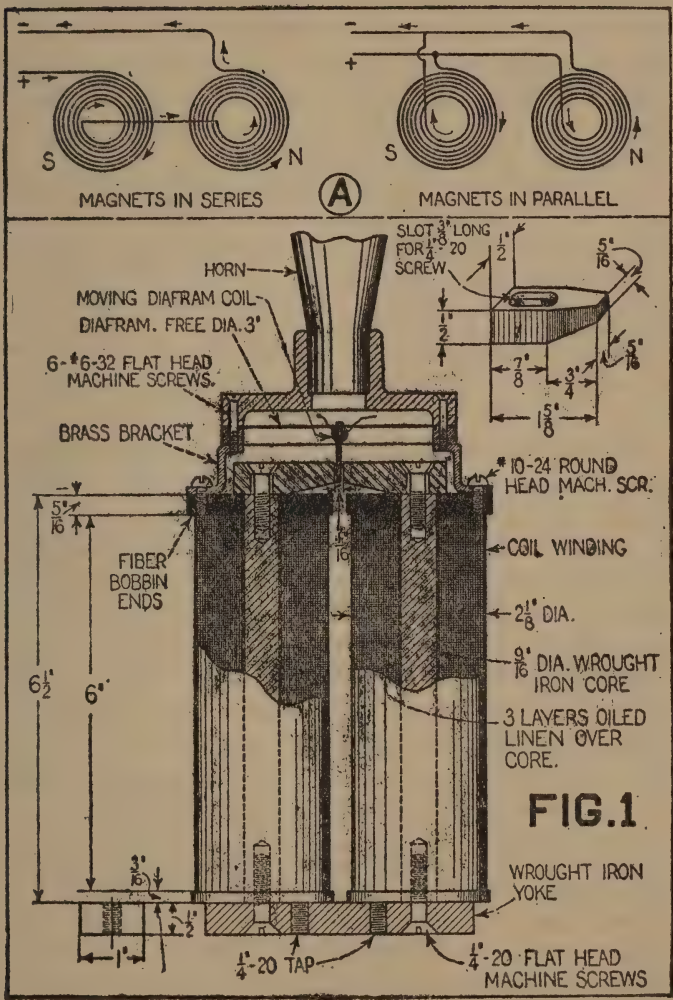


FIG.1

LOUD TALKERS—HOW TO BUILD THEM

both ends, and also the yoke is drilled and tapped for the same sized thread to accommodate two similar size screws for the purpose of mounting it rigidly on the base.

The method of connecting up the two electro-magnet spools is shown at Fig. 1-A, both for series and also for parallel connections, more about which will be said later.

The wrought iron pole-pieces are to be made according to the dimensions given at Fig. 1, and should have slots drilled and filed in them with a rat-tail file, so that when the complete electro-magnet is assembled the two pole-faces can be approached to within $1/16$ inch of each other, or, in fact, a little closer.

Current Consumed by Electro-Magnet

The electro-magnet as described was especially calculated for operating on battery potential such as storage battery current. The resistance of each spool or No. 20 wire coil will be about 9.45 ohms or 18.9 ohms for the two coils when connected in series. If you have 24 volts available, say from dry or storage batteries, or else from a dynamo, then the current will be E divided by R , or 24 volts divided by 18.9 ohms, which gives 1.27 amperes.

If only 12 volts D. C. is available, then the two coils may be connected in parallel and the current will then be twice that at 24 volts potential, or 2.54 amperes, and the current at 6 volts will be about 5.08 amperes.

Where the electro-magnet is to be operated on 110-volt direct current, such as from a lighting circuit, the size of wire is made proportionately smaller and, in fact, inversely to the ratio between the voltage here designed for, and the higher voltage; in this case, 110 volts. In other words, the inverse ratio between 24 volts and 110

volts is about one-fourth, and the size of wire chosen for the higher potential should have about one-fourth the cross-sectional area in circular mils.

The current taken at 110 volts D. C. will, of course, now be about one-fourth that consumed at 24 volts, or about one-third ampere. The two magnet coils would be connected in series under these considerations, for 110-volt service, when wound with the finer wire.

Building the Moving Diaphragm Coil

One of the most delicate parts of the entire apparatus must now be constructed. This is the small wedge-shaped moving coil, mounted on the lower side of the diaphragm. This coil manifests an up and down or vertical movement when carrying a current, and when placed between the pole-pieces of the powerful electro-magnet. This moving coil has been tried with a resistance value of differing magnitude, and the resistance to be used will depend upon the purpose to which the amplifier or loud-talker is to be adapted.

However, if the moving coil is wound to have 60 to 75 ohms resistance, then it can be used for radio or other work where the current is of relatively high potential, or low current (amperage) value by interposing in the circuit a suitable step-down transformer. Where this loud-talker is to be used for amplifying or reproducing the spoken voice, an ordinary microphone is connected directly in series with a battery of several cells and the moving coil.

Figure 2-A shows the simplest method of building the moving diaphragm coil. The winding of this coil requires

33 feet of No. 36 enamelled or single silk covered wire for a resistance of about 14 ohms, suitable for use with the step-down transformer previously described. The coil may be wound to an even thickness of about $\frac{1}{8}$ inch on a standard wooden form, the same as any ordinary form-wound magnet coil.

A single silk covered copper magnet wire is preferable. The coil should have several strings tied around it, the strings having been placed in the form before the winding was started and tied around the coil before removing it from the three-part collapsible form.

After the coil has been removed, it can then, with a little care and ingenuity, be worked slowly and gradually into the desired shape, as shown in the stages 1 to 4 in Fig. 2-A. The coil should be shellacked while this forming operation is in progress, so that by the time it has been finally worked to the shape shown at the fourth stage, i. e., having a flat thin base like a knife or wedge, a little under $\frac{1}{16}$ inch thick, the shellac will begin to harden and the coil caused to hold its shape. It may be necessary to place a weight upon the flattened portion of the coil, in order to cause it to maintain an even flat shape, and the top can be tied with several strings so as to preserve its rounded-out form.

The round-shaped portion at the top of the coil is to be gripped by the spring clip made of bronze or brass, shown at 5 in Fig. 2-A. This clip may be riveted to the center of the under surface of the diaphragm.

To those desiring to work out the coil more exactly and also to provide a standard form on which further coils can be wound to exact shape at the start, the scheme illustrated in Fig. 2-B will, perhaps, appeal more strongly.

With a little patience this three-part wooden, fibre or metal form can easily be made, the dimensions being checked up from those given in connection with the coil

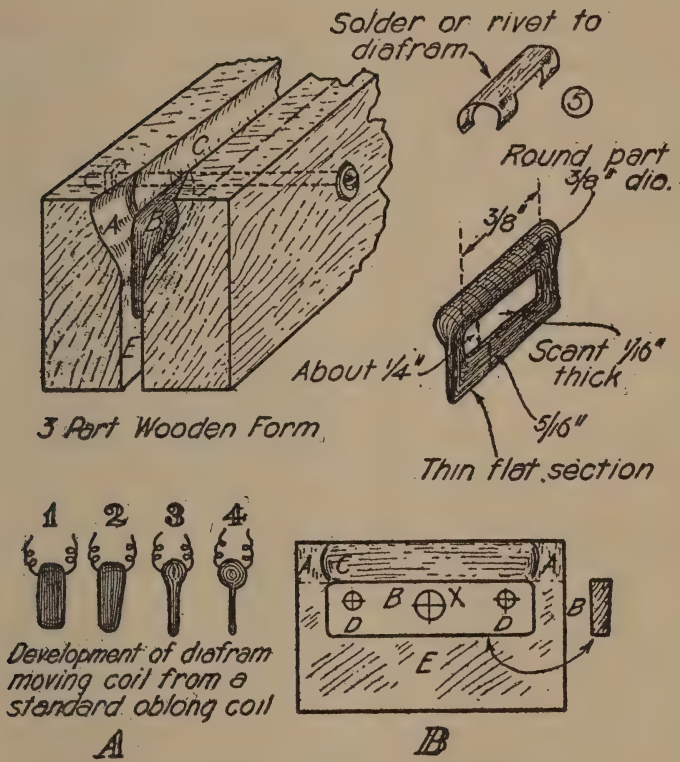


Fig. 2

drawing in Fig. 2-A. One or two machine screws and nuts passed through holes drilled through the three-part form, will hold it tightly together while the coil is being wound.

The edges of the winding block B should be carefully rounded so as to avoid sharp corners, and the curvature at the top edges may be more pronounced than that at the bottom edges.

It will be seen that the flat part of the coil is thus automatically wound at the first operation in the space E, which should be about $1/16$ inch wide only. By carefully curving the ends of the two outside form blocks at AA, more room for the winding operation will be obtained, and the gradually tapering form of the coil easily obtained while the form is revolving on a central axis or shaft X.

Small lengths of thread should be placed in the form at Fig. 2-B before the winding is started, so that after the turns are all wound on, the threads may be pulled over and tied so as to bind the coil in a compact manner. The screws holding the form together can then be removed, the two sides separated and the center block gently pushed out of the coil. The coil should be carefully examined, tested for continuity with a telephone receiver and battery, then dipped in insulating varnish or thin shellac, and allowed to dry thoroughly.

Several strings may have to be tied along the flat lower portion or else a piece of paper wrapped around it and a weighted block placed on the flat portion while it is drying to render it perfectly flat and even in thickness. The paper may be left on if it is quite thin, after the coil is dry and ready for use. Placing the weighted coil on a slightly hot plate will dry and bake it quickly.

The experimenter should build several of these coils of different resistances, for he will find that various coils work best under certain conditions and for certain purposes. Instead of stepping down the current from the

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FIG. 3

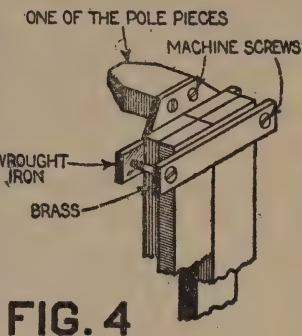
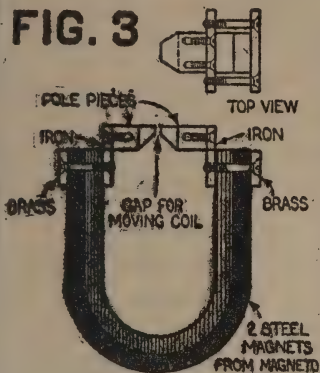


FIG. 4

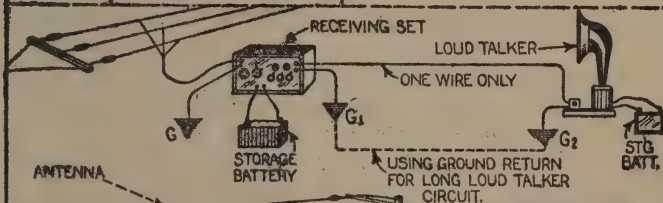


FIG. 6

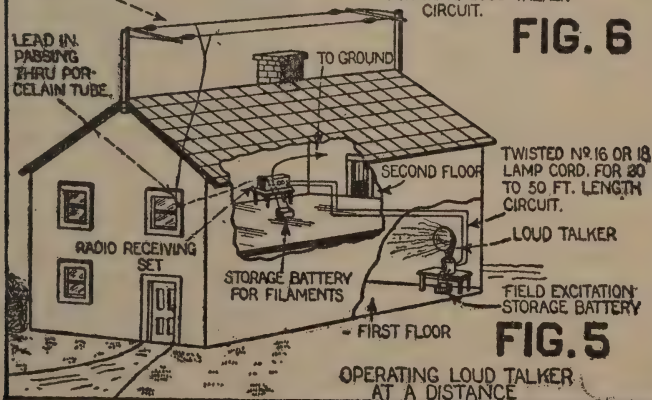


FIG. 5

audion amplifier circuit, the coil might be wound with very fine wire such as No. 50, so as to have a resistance of from 500 to 1000 ohms. The fine wire leads from the coil should be wound around a nail or other small object so as to give sufficient flexibility to them, and they can be later secured to suitable terminals on the instrument.

A piece of thin silk or paper should be placed around the circular top of the coil, so that the clip which is to hold it will not damage it.

The diaphragm may be of mica about .006 to .008 inch thick or else of phosphor bronze or German silver. Various thickness and diameters of diaphragms can be experimented with until the most effective result with a certain strength of magnet and amplifying circuit is obtained.

If you have a phonograph sound box or reproducer having a diaphragm about $2\frac{1}{2}$ inches to 3 inches on its free or vibrating diameter, you can use this very well instead of building one. If you have to build the diaphragm rings and support, the idea for making this part will be readily obtained from the drawing Fig. 1. This comprises simply two rings of brass or other non-magnetic metal, with a tubular part extending at the top to make firm connection with the amplifying horn or chamber.

The rings should be clamped together by six or eight No. 8-32 machine screws, which can be threaded into the lower ring, except at the two diametrically opposite points, where the screws should thread into the two brass brackets supporting the diaphragm ring. About one-quarter inch air space should be left between the diaphragm and the inner face of the top clamping ring as shown.

Precautionary Remarks

In the final assembly the points to be watched are the following: That the polarity of the two upper pole-pieces of the electro-magnet are N. and S. respectively, and this can be checked by means of the diagram Fig. 1-A. The flat lower part of the diaphragm coils should move freely up and down for a distance of about $1/16$ inch between the pole-pieces and these should not be separated much over $1/16$ inch. Thinner coils with smaller air gaps between the pole-pieces may advantageously be experimented upon, as this is one of the most important factors having to do with the efficiency of this particular type of apparatus.

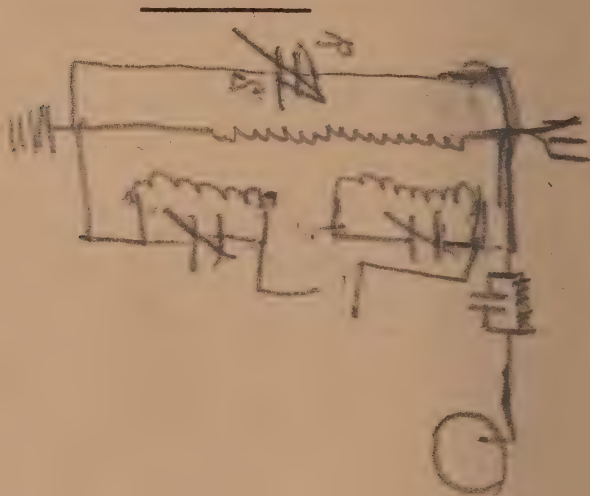
In connecting the moving coil element with a microphone and battery current, for the purpose of using it as a regular telephonic loud-talker, care should be taken to see that not too high a potential is applied; usually about 10 to 15 volts will be found sufficient. For those desirous of obtaining much louder reproduction of signals a somewhat more powerful electro-magnet may be built and the calculations for the windings of such can be made with little trouble.

Miscellaneous Remarks

Instead of using electro-magnets for the field of the loud-talker, permanent steel magnets may, of course, be utilized, as shown at Figs. 3 and 4, Fig. 4 showing how to employ four or more magnets by clamping the pole-pieces to them. Fig. 5 shows how a loud-talker can be hooked up on a different floor than that on which the receiving set is placed. Fig. 6 illustrates how a loud-

LOUD TALKERS—HOW TO BUILD THEM

talker was used at a hotel, one wire only being run to the loud-talker, nine stories below the receiving set. The circuit was grounded at G1 and G2 as shown in the diagram. Very good results have been obtained by the author with an audion amplifier set, using the ground wire only, leaving the aerial disconnected. Others have also found this trick to work very well.



CHAPTER III.

Improved Loud-Talkers

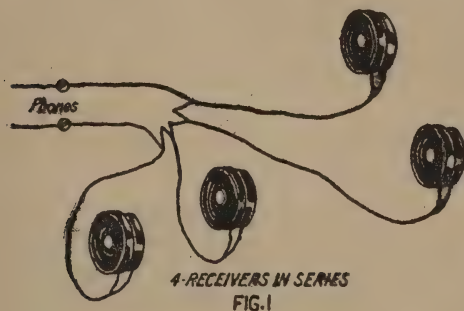
L OUD-TALKERS, which are frequently nothing more than a specially devised telephone receiver fitted with a horn in some fashion or other, have become a very important topic of conversation among radio enthusiasts. Loud-talkers and so-called amplifying chambers for them, such as used in our phonographs have become of such importance that a few words on this subject of what actually occurs in such horns may not be amiss. As pointed out in a recent interview with Mr. O. B. Blackwell, well-known telephone engineer of New York City, and also by Prof. Dayton C. Miller, of the Case School of Applied Science, there is actually no amplification of sound produced in any horn. That is to say, there is no amplification of the energy which is put into the telephone receiver or phonograph reproducer diaphragm, the horn simply acting as an acoustic or sound relay; and its function is to connect the vibrating diaphragm of the receiver or reproducer with the air in the room. There are many erroneous ideas entertained regarding the horns used on such instruments, and one of the greatest fallacies is that the horn is never any good if it is straight, but that it should be curved or coiled into several artistic knots and loops, as are the big brass base horns and similar instruments played by the village band. The reason why such band instruments have a tubular chamber wound around in a coil several times, is not because the

sound is any stronger or better because it has, perchance, to follow around the innumerable corners and twists; but is due to the simple fact, as pointed out by Prof. Dayton C. Miller, that in order to permit a resonant acoustic or sound chamber to function at maximum efficiency for a certain tone, we must make this chamber of a fair length. The average tone register, let us say, is a baritone, which is between the high and the low notes usually sung or played, and the proper length of horn for an average baritone note is four and one-half feet, which corresponds to the length of this wave or vibration in air. If the horn is a great deal shorter than this wave length, it will vibrate at but a partial tone, or, in other words, our acoustic relay, as it were, will have to set up this note by vibrating a volume of air equivalent to one of its harmonics or a partial wave length.

To build a first-class horn, make it good and solid of some hardwood like mahogany, oak or maple; polish the inside as smooth as possible with sandpaper, and give it a coat or two of good varnish or shellac. "The horn must be tight at every point," said Prof. Miller, "and if we will remember that we are simply vibrating a column of air which is contained within our horn, we shall have a clear conception of just how we must build this chamber." In other words, the walls should be sufficiently heavy and solid to insure that only the column of air is vibrating, and not the horn itself. Of course, this result is never achieved with a metal or tin horn, unless it is made of drawn or pressed steel at least one-sixteenth inch thick. The material forming the horn should not sing or vibrate, and the best music Prof. Miller ever heard from a phonograph, he told the author, was that produced from a concrete horn over seven feet long,

with walls four inches thick. In other words, wood one-quarter to one-half inch thick is better for building such horns from than thin wood, and many of the better class phonographs are now being fitted, it is noticeable, with very substantial sound chambers having wood at least one-half inch thick.

Of course a loud-talker is of little or no use to those who are using simply a crystal detector or one audion, but where two or more audions are employed, then the



loud-talker comes into demand. It may not be so convenient, perhaps, but as Fig. 1 shows, it is frequently more efficient to separate the individual receivers from two or more double head-sets, and allow each person to have one receiver, connecting the individual receivers in series as indicated in the diagram. This is done for the reason that usually there is but little current and a relatively greater voltage available at the receiving set output terminals, especially where a crystal detector is in use. The voltage available will thus actuate two to four, or even more 1000 ohm receivers in series as readily as it will one; but the current available is so slight that if

the phones were connected in parallel the increased amperage demanded by this arrangement would be more than the set supplied. It has been found in many cases, however, where multiple stage vacuum-tube amplifiers are in use, that additional phones or head sets can be connected in parallel, owing to the reversal of the foregoing conditions in this case, there being a greater amperage available, which meets the demands of the successive phones connected in parallel.

A question frequently asked is, "Will the signals be of the same strength if two receivers or head sets are connected in series instead of using the single receiver or head set?" Usually the strength of a signal is but



slightly reduced, and where audion amplifiers are employed there is invariably sufficient energy in the output circuit to energize from six to twelve phones or more.

A very good loud-talker, which has been tried out by the author with excellent success, is that shown in Fig. 2. This comprises a metal horn, the size of which may vary, but, of course, the larger the horn the more volume of sound produced. A single Baldwin type "C" amplifying phone is employed. A Brown adjustable magnet receiver

is very good also, and is used in the "Vocaloud" loud-talker. The Baldwin type "C" receiver, which is extra large in size and fitted with a mica diaphragm, gives a very clear articulation, much better than many of the high-priced loud-talkers now on the market, and it is connected in place of the regular head phones. A very good arrangement is to connect the output terminals of the audion amplifying set to the two blades of a double-pole, double-throw, knife switch. To one set of switch jaws the terminals of a regular 2000 ohm telephone head set are connected, while to the opposite set of switch jaws, the terminals of the loud-talker are connected. Some radio amateurs have complained that they had to re-tune their set slightly after throwing the switch over to the loud-talker, having tuned in the station loud and clear in the head phones first, but the author has found that if flexible twisted lamp cord not over five feet long is used to join this loud-talker to the switch, no change in tuning has to be made at all, using a detector and three-step V.T. amplifier. Some re-tuning is necessary where long leads connect the loud-talker to the audion cabinet.

There are a number of different ways in which this amplifying receiver can be held firmly and tightly against the board connecting it acoustically with the amplifying horn, and a very effective method of doing this is shown in Fig. 2. The receiver may be wired or held with a leather strap tightly against the board in which the base of the horn is fastened, but the method illustrated comprising a spring which presses the receiver against the felt-covered front board, will be found simple, and besides the receiver can be easily removed at any time. Where a large horn cannot be obtained, a smaller one

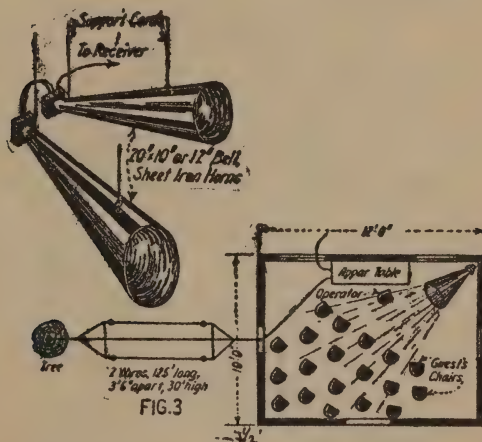
may be purchased and then enlarged in size by purchasing a piece of fairly heavy sheet iron and bending this to fit inside the horn, as the author has done. It will take some careful fitting to bend the sheet iron cornucopia fashion, but if you are a bit skilful with a mallet and a wooden block, you can form a flare or bell at the mouth of the horn.

Duplex and Triplex Loud-Talker

A friend of the author's has successfully used, and is using at the present time, on a four-vacuum-tube receiving set, with a loop aerial three and one-half feet square, the duplex loud-talker shown at Fig. 3. Here two Baldwin phones are used, one for each horn, and the two horns are arranged to face in different directions, so as to distribute the sound around the room in the best manner possible. These horns can face in any direction desired; in a long, narrow room, for example, they may be placed back to back, so as to face in opposite directions, and thus throw the sound to the respective ends of the room. The horns used in this case measure about 20 inches long and have an opening at the larger end of about ten inches. The 1000 ohm receivers are held in wooden blocks, similar to the plan shown at Fig. 2. The horns are best suspended by cord or rope from the ceiling, but wire may be used if care is taken to see that it does not sing on certain notes.

In Fig. 3, the arrangement of chairs, apparatus table, and single loud-talker with extra large horn of the type shown at Fig. 2, is outlined. In a small room especially, always place the loud-talker in a corner and near the ceiling if possible, as this serves to distribute the sound to the best advantage about the room; one peculiar fact

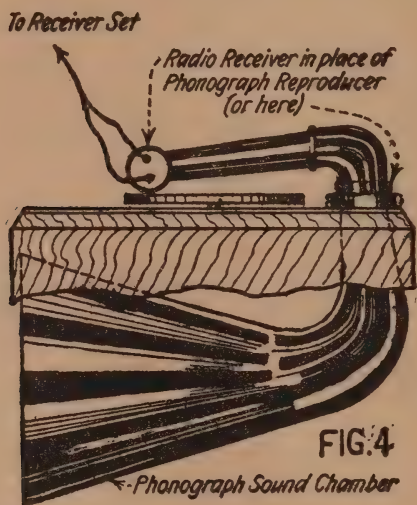
is that the radiophone talk always sounds much clearer at a fair distance from the loud-talker, this being due in part to the fact that when one sits close to the horn of the amplifier, he usually hears a slight frying noise or hissing, due to the action of the audions. Sometimes a radio-telegraph station interferes, and if this is rather weak, this interference will be lost when the radiophone



is sharply and clearly tuned in, and providing you do not sit too close to the loud-talker. Where a large room or auditorium is to be filled with sound from a loud-talker and radiophone receiving set, several large horns, either of metal or wood, may be placed either in the respective corners of the hall or else they may be grouped in the center, the large openings of the horns pointing outward, so as to distribute the sound equally in all directions.

Phonographs Make Good Loud-Talkers

Many people are using their phonograph amplifying chambers as horns for radio loud-talkers with very good results. There are two general methods of doing this, as shown in the diagram at Fig. 4. The radio receivers, or at least one of them, are placed at the end of the tone-



arm to take the place of the regular reproducer, or if this is not possible, owing to difficulty in removing the reproducer, the tone-arm may be unscrewed from the shelf, and the radio receiver placed, face downward, over the opening in the amplifying chamber. It is preferable to place the receiver at the end of the tone arm in the position previously occupied by the reproducer, as the

metal tone-arm in most cases has a well defined taper to it, and the sound has a chance to swell out slowly, as the size of the tube gradually increases.

Mr. Howard Brown constructed a very satisfying loud-speaker, using a wooden chopping bowl which can be purchased at any kitchen utensils store. (See Fig. 5.)

The inside of the wooden bowl was thoroughly sand-papared, the bowl measuring about twelve inches in diameter and five inches in depth. When it was perfectly

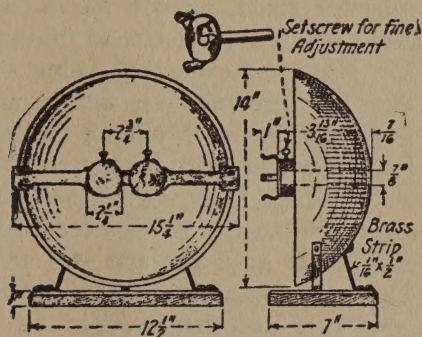
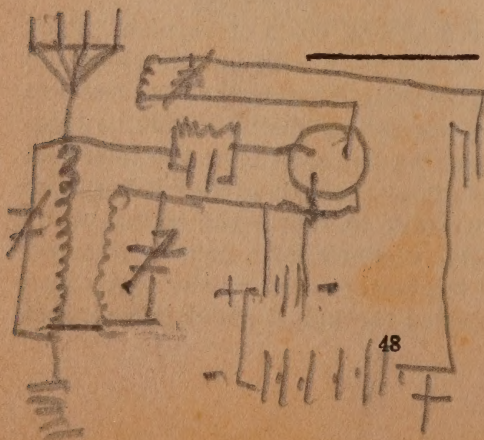


Fig. 5

smooth it then received several coats of varnish. Each coat of varnish was rubbed down with pumice stone and oil, so as to be thoroughly smooth before the next coat was applied. Each coat of varnish or shellac should be thoroughly dry before applying the next one; the final coat should be as hard and dry as possible, even if it has to be baked in an oven, in order to reflect the sound waves efficiently. A thin piece of wood (or a metal strip) was then mounted across the bowl exactly on the center line, and two holes were drilled through it about three inches

apart off centers. These holes, about $\frac{7}{8}$ inch in diameter, have two horns about $3\frac{1}{2}$ inches long fitted into them, the horns being of metal or fibre, and slightly expanding at their outer ends. Each receiver of a head set was then secured over the respective holes and with four audions and using an indoor aerial, comprising simply a few wires stretched across the room from the picture molding on one side of the room to that on the other side, a large room was filled with music, loud, clear and thoroughly satisfying.

A wooden chopping bowl is very excellent material to make this reflector from, as will be evident from the foregoing theory of acoustic horns as discussed by Prof. Miller and Mr. Blackwell, the cost being so small that every radio-bug can procure one, but in an emergency and where it simply is not available for one reason or another, a tin, or better still, an agateware or enamel wash basin will fill the bill in pretty good fashion. It is a simple matter also to try out a porcelain wash bowl, and this is of a pretty good size and of a different curvature also. They are certainly solid and firm, and there is hardly a smoother and firmer reflecting surface than glazed porcelain.



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